July, 2012

Staphylococcus aureus Infections in Montana Hospital Admissions, 2000-2011[1]

Carol Ballew, PhD, Senior Public Health Epidemiologist
Cody Custis, MS, Montana Hospital Discharge Data System Epidemiologist

Staphylococcus aureus is a common bacterium that can cause both superficial and systemic infections.[2,3] Approximately 20% of healthy individuals are persistent carriers of *S aureus* and up to 60% may have intermittent infections.[4] Patients may acquire *S aureus* infections in the hospital or they may be admitted with them. Regardless of the source, these infections are increasingly common complications of hospital admissions, causing a growing burden of disease in their own right and complicating treatment of many other conditions. Antibiotic resistant strains of *S aureus* (MRSA) were first reported in the 1960s.[5] The proportion of MRSA among hospitalized patients with *S aureus* infections nationwide rose from approximately 2% in 1975 to more than 50% in the general patient population in 2004, and to more than 60% in ICUs.[6] Length of stay, cost of hospitalization, and in-hospital mortality rates are higher among patients with *S aureus* infections, particularly MRSA strains, than those without, but this is confounded by the fact that patients with *S aureus* and especially MRSA infections are often older and suffer from more comorbidities than patients without such infections.[7] Young children and the elderly are particularly vulnerable.[8] Excess costs associated with *S aureus* and MRSA hospitalizations are attributed primarily to longer stays and greater demands on nursing care.[3,9]

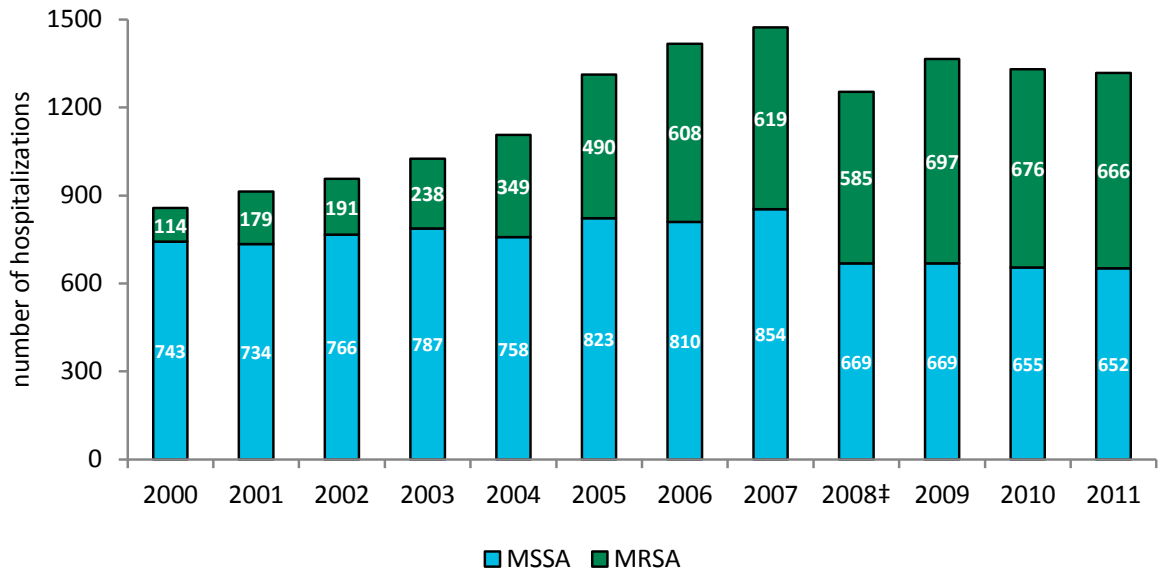
The most common conditions associated *S aureus* infections in general and MRSA in particular are hospital-acquired pneumonia, especially with use of a ventilator; surgical site infection; bacteremia associated with indwelling catheters and central lines; cardiovascular surgery with implanted devices; and orthopedic surgery. In addition, dialysis patients and those with diabetic foot ulcers are disproportionately affected by *S aureus* and MRSA.[3,7] As a result, *S aureus* infections can be associated with a wide variety of primary diagnosis codes. Apart from pneumonia due to *Staphylococcus* (ICD-9-CM code 482.2)[10] and Staphylococcal septicemia (038.1), diagnosis codes prior to 2008 were not strain-specific, and had to be cross-coded with secondary diagnosis codes for infection with *S aureus* (041.1). Infections with a code of V09.0 (infection with microorganisms resistant to penicillin) or V09.1 (resistant to cephalosporin and β-lactam) among secondary diagnoses, along with an *S aureus* infection code, were considered MRSA. Beginning on October 1, 2008, coding for *S aureus* was revised with the addition of new codes specifically for

[1] The Montana Hospital Discharge Data System (MHDDS) receives annual de-identified hospital discharge data sets through a Memorandum of Agreement with the Montana Hospital Association and the Montana State Hospital at Warm Springs. Most hospitals in Montana participate in voluntary reporting of discharge data from their Uniform Billing Forms, version 2004 (UB-04). The MHDDS receives information on more than 95% of the inpatient admissions in the state. It does not receive data on Emergency Department visits at this time.
[2] Lowy FD. 1998. *NEJM* 339:520-532.
[3] Shorr AF. 2007. *Pharmacoeconomics* 25:751-768.
[4] Kluytmans J et al. 1997. *Clin Microbiol Rev* 10:505-520.
[5] Jevons MP et al. 1963. *Lancet* 1:904-907.
[6] Boucher HW, Corey GR. 2008. *Clin Infect Dis* 46(suppl 5):S344-S349; Panlilio AL et al. 1992. *Infect Control Hosp Epidemiol* 13:582-586;
[7] Malani PN et al. 2008. *J Am Geriatr Soc* 56:1485-1489; McHugh CG, Riley LW. 2004. *Infect Control Hosp Epidemiol* 25:425-430; Cosgrove SE et al. 2003. *Clin Infect Dis* 36:53-59; Cosgrove SE et al. 2005. *Infect Control Hosp Epidemiol* 26:166-174; Noskin GA et al. 2005. *Arch Intern Med* 165:1756-1761.
[8] Collins A et al. 2007. *MMWR* 56:197-199.
[9] Nathwani D. 2003. *J Anthmicrob Chemother* 51(suppl 2):ii37-ii44.
[10] http://icd9cm.chrisendres.com/

MRSA infections (482.42, 038.12, 041.12) with the previous codes being used exclusively for antibiotic-susceptible (MSSA) infections (482.41, 038.11, 041.11). V-codes are no longer used to identify MRSA.[11] The MRSA-specific codes are expected to improve identification of MRSA-related hospitalizations. Because of coding and billing conventions, *S aureus* infections are not usually listed as a primary diagnosis in the MHDDS: *S aureus* infection was listed as the primary diagnosis in only 17% of cases with MSSA and 14% of cases with MRSA from 2000-2011.

In Montana in 2011, 1.4% of all hospitalizations had secondary codes indicating *S aureus* infections. The proportion of *S aureus* infections attributed to MRSA increased from 13% in 2000 to 51% in 2011 (Figure 1). The number of MSSA infections remained nearly constant through 2007, then declined following the coding revision in October, 2008. The number of MRSA infections increased from 114 in 2000 to 666 in 2011. MRSA has accounted for 51% of all *S aureus* infections each year since 2009.

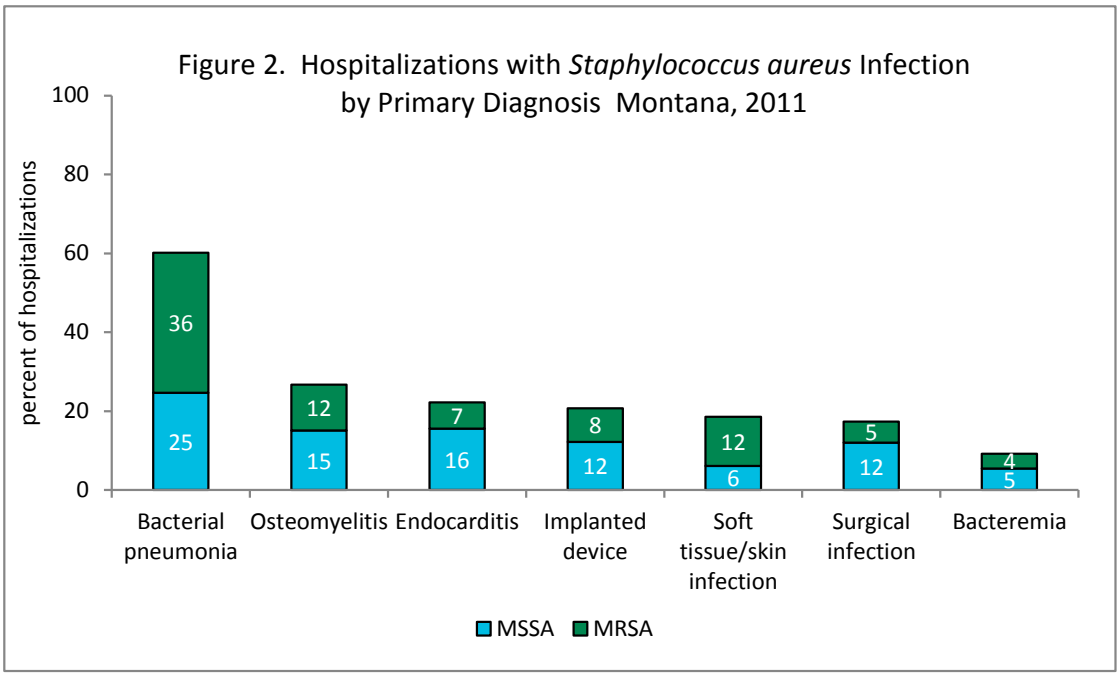
Figure 1. Hospitalizations with *Staphylococcus aureus* Infections
Montana, 2000-2011



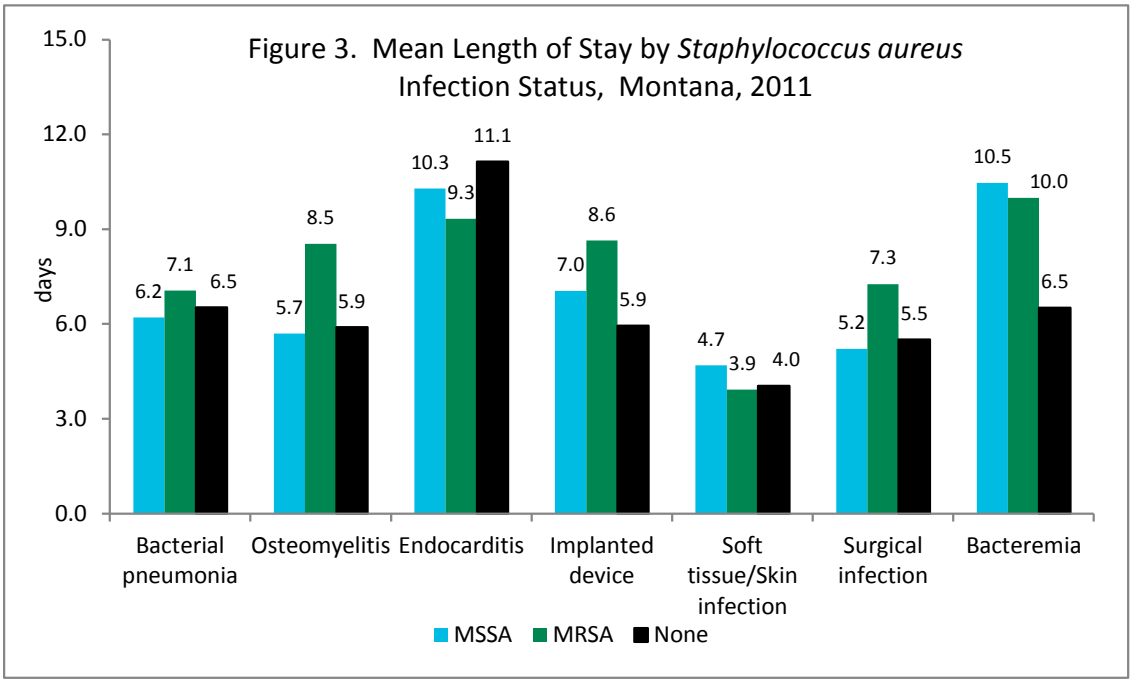
‡ Coding revision occurred in October, 2008.

The most common primary diagnoses associated with *S aureus* infection, in declining order, were bacterial pneumonia, osteomyelitis, endocarditis, implanted devices, skin and soft tissue infections, surgical infections, and bacteremia (Figure 2). More than half of all hospitalizations with bacterial pneumonia, more than one quarter with osteomyelitis, and about 20% with endocarditis, implanted devices, skin and soft tissue infections and surgical site infections were associated with *S aureus*. These primary diagnoses accounted for 91% of all cases with MSSA and 84% of all cases with MRSA.

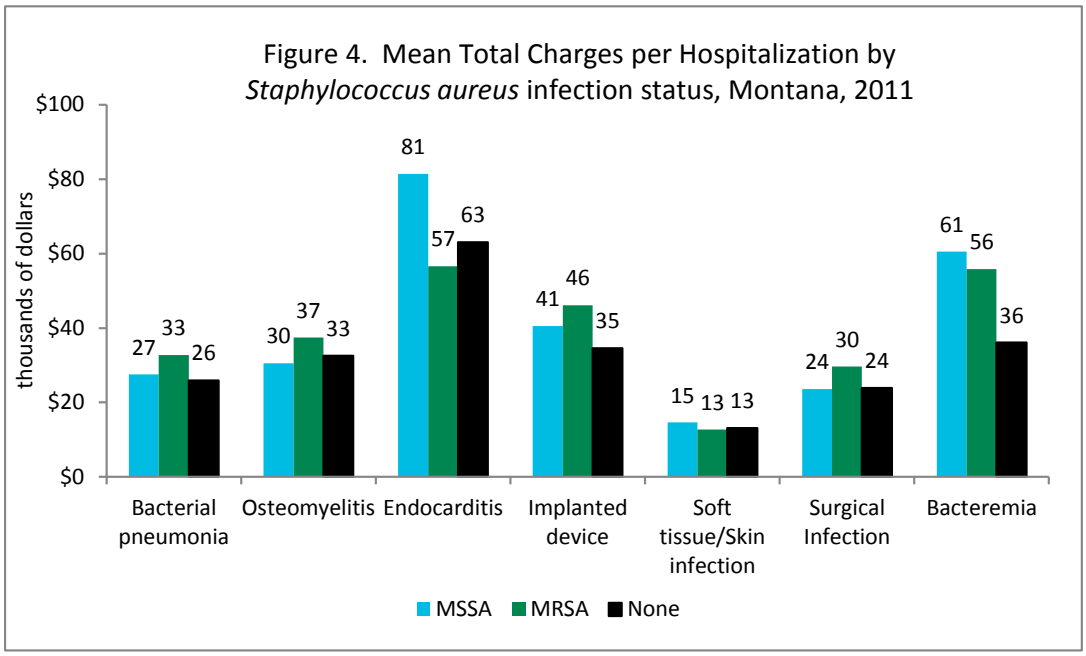
[11] Byrd KK et al. 2009. *Clin Infect Dis* 49:1009-1015.



Hospital stays complicated by MRSA or MSSA were an average of 6.9 and 7.3 days, respectively, compared to an average of 3.8 days for those without *S aureus* infection. The greatest differences were observed in hospitalizations for bacteremia for both MRSA and MSSA (Figure 3). The next greatest increases were observed for osteomyelitis, implanted devises, and surgical site infections for MRSA.



For all diagnoses combined, mean total charges per hospitalization were higher in hospitalizations complicated by MSSA ($38,490) and MRSA ($32,323) than those without *S aureus* infections ($19,499). The difference in charges varied substantially by primary diagnosis (Figure 4). Excess charges for both MSSA and MRSA were greatest for bacteremia. Excess charges were also high for endocarditis complicated by MSSA and for implanted devices complicated by MRSA. Excess charges were highly correlated with longer stays.



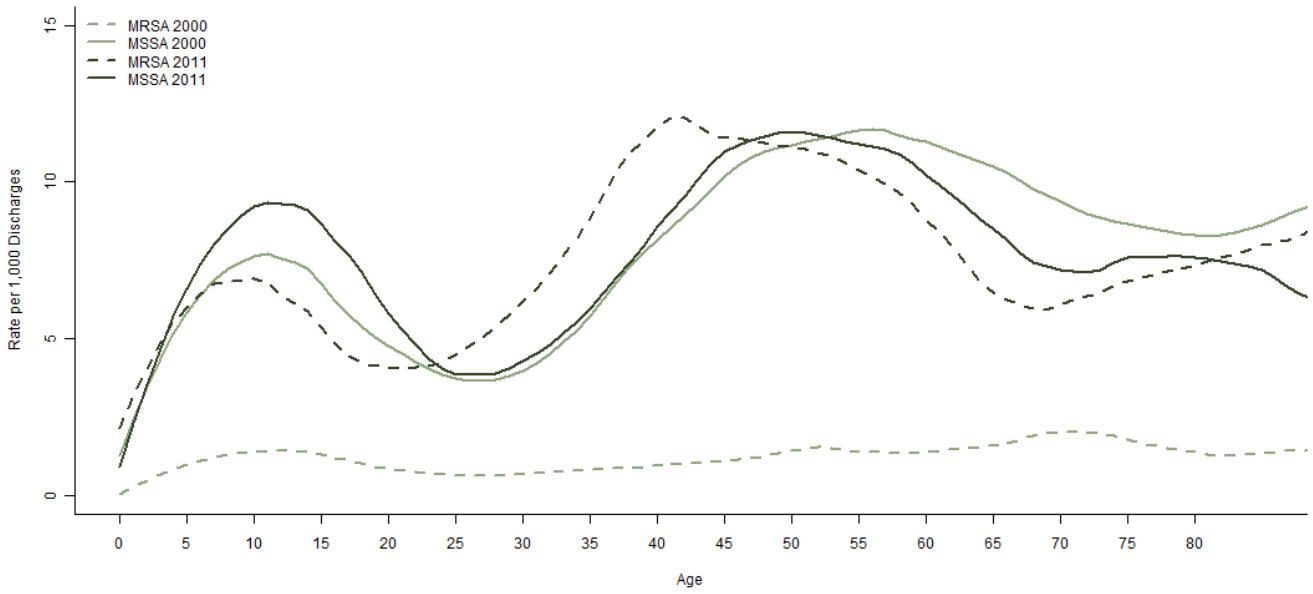
In 2011, patients with *S aureus* infections were more often transferred from other health care facilities, especially nursing homes, than patients without *S aureus* infections (14% and 7%, respectively). Patients with *S aureus* infections were substantially more likely than those without *S aureus* infections to be discharged to another care facility (40%) or to home with care (19%). For some patients, this may reflect a return to the facility from which they were transferred. It may also attributable to increased morbidity as a result of *S aureus* infections, or may be attributable in part to the fact that patients with *S aureus* infections were older (average age 54.4 years and 55.6 years, MRSA and MSSA respectively) and had more comorbidites (average of 7.9 and 8.0 diagnosis fields completed on the billing form, respectively) than patients without *S aureus* infections (average age 48.1 years and 6.5 fields).

Figure 5 shows the age distributions of MSSA (solid lines) and MRSA (dotted lines) *S aureus* infections in 2000 and 2011.[12] The rates of *S aureus* infections per 1,000 hospitalizations were highest for children under age 10 years in both years, although the number of hospitalizations and the number of cases of MRSA were very small for children in 2000 and the rate may therefore be statistically unreliable. The rates for MSSA infections among children in 2000, and for both MRSA and MSSA among children in 2011, are based on larger numbers of events and are likely to be reliable. In 2000, the rate of MRSA infections was notably low and fairly constant after age 20 years, while the rate of MSSA infections peaked at about 10 years, declined in

[12] Infection rates for single year of age are smoothed, using a LOESS smoother in R. R Development Core Team. 2009. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, http://www.R-project.org

early adulthood, then began to increase to peak again after age 50 years. In 2011, a similar bimodal age distribution was noted, but the proportion of MRSA to MSSA was much higher, consistent with the findings that nearly half of all *S aureus* infections were MRSA in 2009 (Figure 1). There was a clear excess of MRSA infections among children in 2011.

Figure 5: *S aureus* Infection By Age, Montana



There were 1,246,065 hospitalizations complicated by S aureus between 2000 and 2011; during this period, 23,550 (1.9%) resulted in a death in the hospital. The effect of *S aureus* infection on mortality is complicated because *S aureus* is disproportionately associated with some of the most severe primary diagnoses and the effect of *S aureus* on mortality varies by primary diagnosis. We computed the Odds Ratios (OR) for mortality associated with any *S aureus* infection relative to absence of *S aureus* infection, controlling for age, primary diagnosis and interactions between infection and primary diagnosis (Table 1).[13]

Table 1. Increased Risk of Dying in Hospital Associated with Any *Staphylococcus aureus* Infection Stratified by Primary Diagnosis, Montana, 2000-2011

		Odds Ratio	95% Confidence Interval
Age (per year)		**1.04**	
Endocarditis		**3.71**	**1.94, 7.08**
Bacterial Pneumonia		**3.12**	**2.11, 4.61**
Implanted Device		**2.37**	**1.35, 4.18**
Bacteremia		**1.31**	**1.11, 1.54**
Soft Tissue / Skin Infection		1.02	0.48, 2.14
Surgical Infection		0.90	0.43, 1.87
Osteomyelitis		0.75	0.36, 1.57

Odds Ratios in **bold** are statistically significantly different from reference category of without infection.

[13] Odds ratios are calculated using age and primary diagnosis (as defined from figure 3) as control variables and *S aureus* infection as an explanatory in logistic regression using PROC LOGISTIC, *Version 9.2 of the SAS System for Windows.*

Under-Ascertainment of *S aureus* and MRSA from Billing Codes

An unknown number of hospitalizations with *S aureus* and MRSA are not identifiable in the MHDDS, which is based on the Universal Billing Form, version 2004 (UB-04).[14] The UB-04 may not have enough fields, or the billing software system used may not use enough fields, to include all infections associated with a given hospitalization, or to include V-codes for antibiotic resistance (before October, 2008) or specific infection codes (after October, 2008). In a study at a large suburban Chicago hospital, covering more than 22,000 discharges over three years, chart review determined that only 31% of patients with MRSA were identified using nine diagnosis fields from the UB-04, and only 59% were identified using 15 diagnosis fields.[15]

The MHDDS and most other hospital discharge data systems receive nine diagnosis fields. Hospitalizations with MRSA have a large number of comorbidites: 71% of hospitalizations with MRSA in Montana from 2000 to 2011 used all nine diagnosis fields, whereas only 43% of all other hospitalizations use all nine fields. The specifics of the Chicago experience cannot be generalized to other hospital discharge data sets but it is likely that there is a substantial but unknown level of under-ascertainment of MRSA, and *S aureus* infections in general, through passive surveillance systems such as a hospital discharge data systems.

For more information about *Staphylococcus aureus*, please contact Karl Milhon at (406) 444-0921 or kmilhon@mt.gov.
For information about the Montana Hospital Discharge Data System, please contact Cody Custis, MHDDS Epidemiologist, Office of Epidemiology and Scientific Support, (406) 444-6947 or ccustis@mt.gov
This document was published in electronic form only. Alternative formats of this document will be provided on request.
Please visit our website at http://www.dphhs.mt.gov/publichealth/epidemiology/mthdds/index.shtml

[14] http://www.ub04.net/
[15] Schaefer MK et al. 2010. *Infect Control Hosp Epidemiol* 31:463-468.